Memo

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Subject: *Normalizing mislocation*

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Introduction

This memo describes how the 90% coverage is actually calculated by taking into account the uncertainties in reference event epicenters. Mislocations may be normalized using a similar methodology.

Coverage parameter

The coverage parameter is calculated by substituting the reference event location into the normal equation of the ellipse:

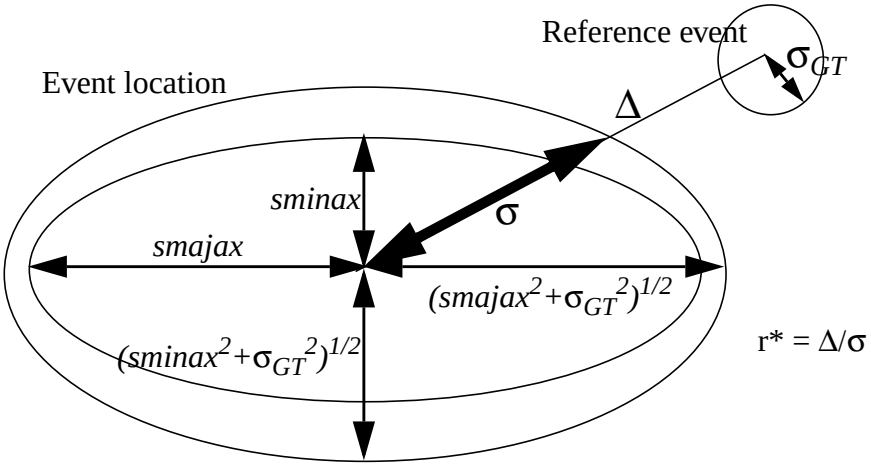
$$\vartheta = (x/smajax)^2 + (y/sminax)^2$$

where the coordinate system is centered on the event location and rotated in a way that the semi-major axis of the 90% coverage ellipse is directed to East, the semi-minor axis to North. *x* and *y* are the coordinates of the ground truth location in the above coordinate system. The coverage parameter ϑ is less or equal than 1 if the error ellipse contains the ground truth location, and larger than 1 if the reference event falls outside the error ellipse. The coverage parameter follows a χ^2 distribution with 2 degrees of freedom.

However, the ground truth location may also have some uncertainty or limited accuracy. To take into consideration the uncertainty in the reference event location, *smajax* and *sminax* in the above equation are replaced by $(smajax^2 + GTaccuracy^2)^{1/2}$ and $(sminax^2 + GTaccuracy^2)^{1/2}$.

Mislocation normalization

Mislocation itself carries little information without accompanying error estimates. In order to present combined mislocation and uncertainty, we weight the mislocation by the extent of bias (both in the ground truth and the seismic network location) along the back-azimuth. This is illustrated in the figure below. In the coordinate system described earlier the normalized mislocation is defined as Δ/σ, where Δ is the mislocation in km and σ is the uncertainty along the back-azimuth in km. Therefore the normalized mislocation is a dimensionless number. It is larger than 1 if the reference event is not covered by the modified error ellipse.



Since coverage is a normalized measure of mislocation, direct comparison of coverage may be misleading; the same absolute mislocation can lead to different values of coverage if the error ellipse varies. Furthermore, if coverage is dominated by the uncertainty in the GT location, it is not possible to determine which location is better. Coverage should be used to test the underlying error model and the power of the data to test hypotheses. This modified coverage statistic assumes that GTX uncertainty, smajax, and sminax are all given at the 90’th confidence percentile.